Coincident mapping of e^+ and e^- from free-free pair production in a magnetic toroidal lepton spectrometer

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Synopsis We discuss the electron-optical properties of a toroidal magnetic sector spectrometer and its suitablilty for electron-positron pair spectroscopy in relativistic ion-atom collisions in the future HESR storage ring at FAIR. With the simultaneous mapping of electrons and positrons and geometric invariants in the lepton trajectorties this instrument offers a very high efficiency for studies of vector momentum correlation in free-free pair production.

Electron–positron pair production, the excitation of an electron with negative energy from the completely filled Dirac sea into an unoccupied state with either a discrete positive energy (resulting in bound-free pairs) or positive energy in a continuum (resulting in free-free pairs) has evolved into a central topic of QED in extreme fields as the coupling between the lepton field and the electromagnetic field is close to one [1-2]. At the future relativistic storage-ring HESR at FAIR [3] such extreme fields may be produced and thus proposed kinematically complete experiments are focussing on momentum spectroscopy of emitted electrons and positrons and corresponding recoil ions.

The kinematic complete study of free-free pair creation $X^{Z+} + A \rightarrow X^{Z+} + \{A^*\} + e^+ + e^-$ demands for the intended spectrometer design to strongly emphasize a large combined detection efficiency (and solid angle) for simultaneous detection of electron and positron of a free-free pair. The electron-optical properties of a magnetic toroidal sector configuration for electrons and positrons were found to be favourable for implementation into a storage ring with a supersonic jet target while covering a wide range of lepton emission into the forward hemisphere. The calculations for the coil configuration adapted to the HESR ring structure, the magnetic B-field and the leptons trajectories in the toroidal B-field are performed using the TOSCA subpackage of the OPERA-3d 17-64 code [4].

Electrons and positrons are simultaneously mapped from the target zone onto large 2D position sensitive detectors in the focal plane in the toroidal magnetic field. We find a geometric invariance of lepton trajectories and describe how these considerably facilitate determination of coincident doubly differential emission cross sections and momentum correlations for electron-positron pairs.

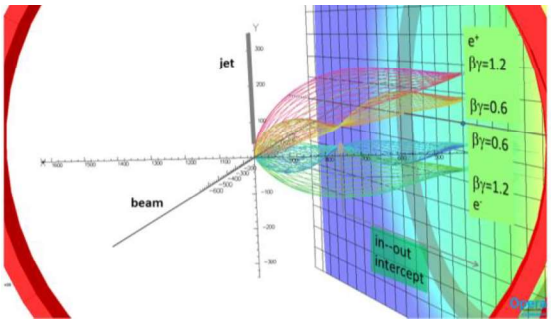

Figure 1. Simultaneous focusing of electrons and positrons of different momenta $\beta\gamma$=1.2/n onto the detector plane, only lepton trajectories for n=1, 2 are shown.

References

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